



Socio-economic analysis in the transport sector

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Socio-economic analysis in the transport sector



DTU Transport Compendium Series part 1

Version 2014

Socio-economic analysis in the transport sector

DTU Transport Compendium Series part 1

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Abbreviations

Abbreviation	Full name
ADT	Average Daily Traffic
B/C	Benefit/Cost
CBA	Cost Benefit Analysis
DC	Driving Costs
DMT	Danish Ministry of Transport
GDP	Gross Domestic Product
GFI	Gross Factor Income
IRR	Internal Rate of Return
MCDA	Multi Criteria Decision Analysis
NPI	Net Price Index
NPV	Net Present Value
NPV/C _{pub}	Present Value per public invested monetary unit
RoH	Rule of a Half
RP	Revealed Preference
SBT	Noise Annoyance Index (StøjBelastningsTal – in Danish)
SP	Stated Preference
TTS	Travel Time Savings
VAT	Value Added Taxes
VoT	Value of Travel time
WTA	Willingness To Accept
WTP	Willingness To Pay

Parameter definitions

Input Factor	Description
Discount rate	This rate is used to fore- or back cast all benefits and costs to same level for comparison. This ratio tends to vary from e.g. 3% in Germany to 5% in Denmark.
Evaluation period	Traditionally in Europe we use an evaluation period of 30 years – however, for larger projects an evaluation period of 50 years is implemented.
Opening year	This is the year when the project is considered open for traffic – traditionally this is the year when the benefits from the projects start.
Calculation year	This is normally the present year where all benefits and costs are respectively fore- or back casted to.
Fixed unit price year	This is year from where the most recent key figure catalogue denotes the fixed unit prices.
Gross domestic product (GDP)	The GDP is used in fore- or back casting time unit prices illustrating people's willingness to pay for a specific item.
Net price index (NPI)	The NPI is used in fore- or back casting general elements within the CBA such as traffic growth etc.
Net taxation factor	The net taxation factor is used to re-calculate or transform the so-called factor prices into market prices hence it is an expression of the average toll/duty paid. This factor is set to 17.1 % in Denmark.
Tax distortion rate	The tax distortion rate is used in public financed projects where the funding is taken from taxes. These impacts account for the competition between private and public funded projects. This rate is set to 20% in Denmark.
Construction period	Large-scale projects tend to have a construction period of more than 2 years which means that the total amount of investments must be discounted to a proper year. The larger the project the longer construction period and vice versa.
Forecast rate/prognosis	This rate describes the future scenario e.g. for traffic growth. This ratio tends to follow the NPI if no other data is available.
Real growth rate	The real growth rate is used as forecast of fixed unit prices and tends to follow the GDP if nothing else is stated.

1 Introduction

This compendium is intended to be a tool for students in conducting socio-economic appraisals in the transport sector following the recommendations made by the Danish Manual for Socio-economic Appraisal (DMT, 2003). The appraisal process is in this compendium outlined as a step-by-step process which is adaptable to all types of infrastructure related problems, and which can be used for decision support on both the administrative as well as the political level.

In the administrative decision process the socio-economic analysis provides a foundation for a systematic examination of which project types or initiatives that are socio-economically most suitable for handling a specific infrastructure problem. Hence, the socio-economic appraisal can help undertaking a sound selection of the possible solutions that should be examined in further details.

The socio-economic analysis is as well an important element in the political decision process. The analysis provides information about how the society's resources – from an economic viewpoint – are used in the best possible way, and how costs and benefits are distributed between e.g. the state, the users and the environment.

The society does not have unlimited economic resources. Thus it is necessary to prioritise between the many projects and initiatives which are being discussed in the public sector. In order to conduct such a comprehensive prioritisation (across different sectors or within the same sector) it is a precondition that a systematic evaluation of the projects/proposals/initiatives' advantages and disadvantages is carried out. For many years cost-benefit analysis (CBA) has been used as the main tool for the purpose of economic comparison not only in Denmark but also in many other countries around the world.

Investment projects that have been prepared thoroughly and evaluated to have a high socio-economic return seem to be able to obtain political acceptance more easily than projects that have not been evaluated through this type of assessment. On the other hand socio-economic assessments can also be used to turn down projects that do not show a satisfactory return.

In the political prioritisation process other considerations of a political, environmental or economic character may influence the decision making. Some of these are not traditionally a part of the socio-economic assessment, but are instead used as a supplement in the final decision phase. The socio-economic assessment strives towards valuing all advantages and disadvantages of a project. On the background of this the project's value for the society is calculated. This value can afterwards be compared to the values for other projects.

The socio-economic appraisal is one of the most basic and tangible contributions to the planning and decision process within the transport sector when an initiative's advantages and disadvantages are to be evaluated. The appraisal can be used both for political decision making as well as internally in organisations with planning related tasks.

2 Principles of socio-economic analysis

Cost-benefit analysis (CBA) is a widely applied method for evaluating the ‘goodness’ of public investments as well as for ranking alternative investments. In short, the basic feature of CBA is the comparison of costs and benefits, which are all measured on the same scale: that of monetary units.

CBA has its origins in the water development projects¹ of the U.S. Army Corps of Engineers. In 1936 the Congress passed the Flood Control Act which contained the wording, ‘the Federal Government should improve or participate in the improvement of navigable waters or their tributaries, including watersheds thereof, for flood-control purposes if the benefits to whomsoever they may accrue are in excess of the estimated costs’. The phrase *if the benefits to whomsoever they may accrue are in excess of the estimated costs* established CBA. Initially the Corps of Engineers developed ad hoc methods for estimating benefits and costs. It wasn't until the 1950s that academic economists discovered that the Corps had developed a system for the economic analysis of public investments. Economists have influenced and improved the Corps’ methods since then and cost-benefit analysis has been adapted to most areas of public decision-making (Salling, 2006). Figure 2.1 shows a timeline of the development in the CBA.



Figure 2.1: Timeline of the development in the CBA

¹ In 1879, Congress created the Mississippi River Commission to ‘prevent destructive floods’. The Commission included civilians but the president had to be an Army engineer and the Corps of Engineers always had veto power over any decision by the Commission.

The idea of supporting decisions regarding new transport infrastructure projects in Europe dates back to the 1960s where CBA was introduced in many countries to examine the viability of, for example, new motorway schemes. Over the years different national approaches have been developed in combination with various impact models. In the 1970s traditional traffic-economic impacts such as changes in travelling time and vehicle operating costs were supplied with estimation of various types of environmental impacts like noise and air pollution. In the 1980s the advancement of CBA methodology was facilitated by the increased calculation possibilities offered by the widespread availability of PCs (Leleur, 2000).

The CBA of a public investment can in some way be compared with the economic analysis carried out by a private company. Such a private company will conduct careful analyses and then make decisions in a way that maximises its future revenue given as the income from products and/or services subtracted costs of production. In such analyses, the private company will use the product's sales price as a measure of the benefit and the prices of production factors as measures of costs. Hence, market prices are the measurement units in a 'private CBA' – i.e. a financial analysis (Gissel, 1999).

Every government instance is confronted with the following problem: it wishes to accomplish more objectives than its resources meaning economic performance will permit. It is hereby necessary to answer two fundamental questions:

- 1) Which objectives should be pursued?
- 2) How should these objectives be accomplished?

When maximising the attainment of the objectives some constraints are of course implied due to the limited resources available. The utilisation of these resources to the maximum is implied in the above questions. In general, the answer to the first question is that an objective should be undertaken only when the value to be derived from achieving it equals or exceeds what must be foregone to achieve it – its cost. The general answer to the second question is that each objective undertaken should be accomplished for the least amount of resources possible – or for the lowest cost. This will assure that the greatest number of objectives can be achieved for the available resources (Salling, 2006).

When considering social welfare, the problem of the decision maker is similar to that of the company management: where the company management wants to maximise the profit, the decision maker considering a public investment wants to maximise the welfare to the society. Therefore he needs to evaluate the change in welfare following the project, i.e. all possible benefits and costs accruing to the society as a consequence of the project.

As society's welfare is based on individual utilities, values of costs and benefits should be derived on the basis of individual preferences where possible. Accordingly, the value of a benefit should be derived as the amount of money an individual is willing to give up to obtain the benefit, and, similarly, the value of a cost element should be derived as the amount of money an individual is willing to accept as a compensation.

Such willingness-to-pay (WTP) and willingness-to-accept (WTA) values are generally not derived by asking individuals directly – such questions would be too difficult to answer (e.g. what would your answer be to the following question: “How much would you be willing to pay for a 6 minutes reduction in travel time?” 2 DKK? 10 DKK? 15 DKK?) and, in some cases, could involve the risk of strategic answers (e.g. if the individual suspects that the willingness-to-pay for the travel time reduction would not be completely hypothetical and that he will be charged extra according to the WTP he states). Instead a variety of indirect methods such as *stated preference* (SP) or *revealed preference* (RP) can be used.

2.1 Rule-of-a-half (RoH)

The WTP and WTA measures can be illustrated graphically by considering a demand curve. A demand curve expresses society’s demand (i.e. its willingness to pay) for a good as a function of its price. (The price may also be a generalised cost comprising other factors than the mere product price).

As an example consider the demand, N , for travel on a given rail section. This demand depends on the ticket price as well as travel time and comfort. Assume that these three factors may be combined into a total generalised cost, c .

The demand curve for trips on the rail section is illustrated in Figure 2.2. In the initial situation there are N_0 travellers who all experience a generalised cost, c_0 . Assume now that an infrastructure repair enables the train to increase speed hence reducing travel time – and thereby the generalised costs (fare and comfort assumed constant) – for the passengers. If the generalised cost reduces to c_1 , demand will increase to N_1 .

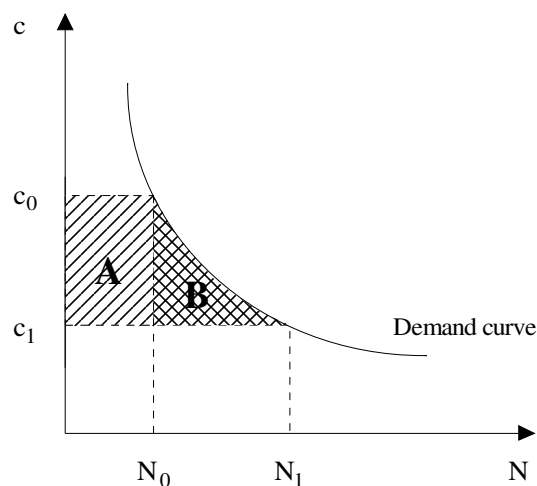


Figure 2.2: Change in consumer surplus measured as the area under the demand curve

The existing N_0 travellers will experience a cost reduction of $c_0 - c_1$, meaning that each of the existing travellers will acquire a benefit of this size. Hence, the total benefit to existing travellers may be described by area A in Figure 2.2.

Consider the N_0+1 'th traveller. Before the reduction in travel time he did not travel because he was only willing to pay (or endure) a cost slightly less than c_0 . After the cost reduction he experiences a cost of c_1 , and as his willingness to pay is higher, he experiences a benefit equal to the vertical distance between c_1 and the demand curve (describing the willingness to pay). Similar reasoning may be applied to traveller N_0+2 up to traveller N_1 , implying that the benefit accruing to the new travellers may be found as the area B in Figure 2.2.

The total benefit of the cost change may thus be described as the area under the demand curve between the 'before' and the 'after' costs (c_0 and c_1) – i.e. the sum of the areas A and B. This is also known as the consumer surplus.

When cost changes are not 'too big' it may be assumed that the demand curve is linear between c_0 and c_1 . Then the change in consumer surplus can be expressed as (2.1):

$$RoH = (c_0 - c_1) \cdot N_0 + \frac{1}{2} \cdot (c_0 - c_1) \cdot (N_1 - N_0) = \frac{1}{2} \cdot (c_0 - c_1) \cdot (N_0 + N_1) \quad (2.1)$$

This expression is often referred to as 'rule-of-a-half' (RoH).

2.2 The value of travel time

Travel time has an alternative value. A traveller will probably prefer spending less time in the train or on the roads and instead have more time for his family, leisure activities or, perhaps, for work. Hence, changes in travel time will be of some value to him.

It is not unreasonable to assign monetary values to changes in travel time. Consider the existence of high-speed trains: they run on the same route as ordinary trains and they provide (more or less) the same comfort. The sole differences between the high-speed train and the ordinary intercity train are with respect to the price and the travel time. When people prefer the high-speed train, they indicate that they are willing to pay money to save travel time. The same reasoning applies with respect to the existence of fast ferries on the same route as ordinary ferries.

Hence, when a public project leads to changes in travel time, such changes should be included in a CBA.

As CBA is based on neoclassic demand theory, it is natural to approach the valuation of travel time changes within the same framework. Hence, with respect to the individual traveller, a change in travel time may be expressed by changes in his marginal utility. In some cases – e.g. in the case of business trips – an employer will also be affected by changes in the travel time of his employee. In these cases, the marginal changes in production resulting from changes in travel time will have to be considered as well.

The willingness to pay for undertaking trips is of course due to a lot of factors but the most important could be summarised under the headlines (ECMT, 2001):

- purpose of the trip

- distance of the trip
- the mode used
- urban or inter-urban conditions
- travel time or waiting time
- personal income and other economic incentives or restrictions

The two main survey methodologies for measuring value of time (VoT) are SP and RP analyses. SP analyses are carried out by interviewing people or using questionnaires and in RP analyses the actual behaviour due to different improvements or impairments of the transport system. The RP methodology will give results that are more in accordance to the current real situation, and the SP method is for this reason only applied when RP is not available.

2.3 Valuation principles

The necessary background for carrying out socio-economic analysis is the valuation of the different types of benefits or effects accruing from the project. In many cases these benefits concern project consequences which are not traded on any market. For these non-marketed effects several different valuation approaches are used, which can be classified as follows (Leleur, 2000).

1. Effects for which prices exist – Here, market based values are available and provide useful information for project evaluation. Consistent treatment of taxes and subsidies is required throughout the evaluation. Where market prices are distorted through regulation or failure to internalise external effects of the analysis (so-called externalities), etc., it may be necessary to take these distortions into account to maintain consistency in the evaluation. The prices obtained in this way, such as the social values of project effects, are sometimes referred to as shadow prices.
2. Effects for which prices can be imputed from quasi-market observations – Here, no direct markets exist, but values can be inferred from observed or stated human behaviour. The principal methods in this connection are RP and SP.
3. Effects for which surrogate prices can be used – These methods make use of indicators such as the cost of replacing a lost asset or amenity as a surrogate for foregone benefits. Such methods suffer from obvious short-comings and are less satisfactory than 1. and 2. above. Nevertheless, used with care, they may provide helpful indications of maximum and minimum values.
4. Effects which can be indicated only by use of quantitative, physical measures – This category comprises effects inappropriate for use with one of the methods above. Noise units, in some frameworks, fall into this category, while in other frameworks either a surrogate or a quasi-market approach has been adopted.
5. Effects which can only be indicated by use of a qualitative description – This category comprises effects, for example landscape values, for which none of the above approaches are relevant. Procedures are available for dealing with these types of effects, based on professional or political judgment.

The gap between factor prices (prices exclusive of taxes and duties) and market prices results in distortion of economic activities. When a project relates to individual behaviour – and their derived utility – the use of factor prices can lead to fallacious conclusions in evaluation, as individuals face market prices and not factor prices. The recommendation from the Danish Ministry of Transport (DMT, 2003) is to use market prices (that is, prices inclusive of taxes and duties) *and* to include in the calculations the change in tax income on the national budget resulting from changes in consumption or tax rates.

2.4 The strengths of CBA

The appealing features of the CBA are quite convincing and well-known. Hence, they are only briefly mentioned here. They may be categorised according to the following overall bullets:

- Transparency
- Comparability / consistency
- Ignorance revelation (through systematic collection of information)

Firstly, the CBA converts all social implications into an absolute monetary measure of the social profitability. It is desirable to be able to sum up all aspects of the decision problem in one simple value.

Secondly, the CBA provides a methodological tool for comparing projects and/or alternatives, which makes it a powerful decision support tool in the planning process; the values on cost and benefit elements are consistent between investments and over time. This means that the social profitability of projects or policies can be compared across sectors and at different points in time.

Thirdly, the CBA requires the collection of detailed information of financial as well as social costs and benefits. This gathering of information improves the basis on which the decision is made and may give valuable insight into the level of ignorance regarding important aspects of the evaluated project or policy (Leleur et al. 2004).

2.5 The weaknesses of CBA

There are of course also well-known problems associated with the CBA method. In short these may be categorised according to the following overall bullets:

- 'False' transparency
- Practical measurement problems
- Inter-generational equity (sustainability)
- Social equity

Firstly, it is difficult to maintain consistency between the theoretical assumptions of the CBA method and the practical application of it, due to the fact that there may be problems involved when estimating unit prices for non-marketed impacts such as travel time savings, emissions, safety, etc. In practice, therefore, compromises are often made on the valuation of such non-marketed impacts, implying that

the resulting unit prices are inherently of a subjective nature – without such subjectivities being visible in the evaluation. This is a problem with the CBA method since the presentation of a single evaluation measure thus implies a ‘false air of objectivity’.

Also, what is seen by most economists as one of the great advantages of CBA, namely its great transparency, is argued by others as the exact opposite: All financial, environmental and social considerations are reduced to a single number – thereby shielding the results behind a technical mystique. This disagreement could be argued as being a matter of taste, but it *is* a real problem if the general public perceives the evaluation method as some kind of ‘black box’.

Secondly, there are impacts which can hardly be quantified or for which it is difficult or even impossible to estimate unit prices. These are especially impacts of a more long-term and/or strategic nature – as for example many environmental impacts (Engelbrecht, 2009).

Thirdly, an important philosophical and moral problem in the evaluation of (long term) impacts is that of the *present* generation valuing an impact, which they may not live to experience. This means that they are valuing such impacts on behalf of the *future* generation(s).

The Brundtland Commission (UN, 1987) defines sustainable development as: ‘development that meets the needs of the present without compromising the ability of future generations to meet their own needs’. With this definition (environmental) sustainability is an issue of equity between generations.

However, the discounting (see Section 3.1) of costs and benefits, which is a fundamental part of the CBA, disregards to some extent the desires and needs of future generations, hence compromising inter-generational equity. Costs that are more than thirty years away become almost valueless when discounting at normal rates. Hence, long-term costs, such as e.g. environmental resource depletion may be effectively ignored in a CBA. Discounting therefore discriminates against future generations by saying that future costs are worth less (weighted lower) than present costs, and that present benefits are worth more than future benefits.

Hence the logic behind discounting derives from the logic of money – that a person would prefer to receive money now than the same amount in the future (the time preference rate is positive). This is because:

1. money obtained now can be invested and earn interest
2. people tend to be impatient (they want to enjoy benefits sooner and costs later)
3. the person might die before he or she gets the money
4. one cannot be sure of getting the money in the future
5. people in the future will probably be better off; money will not be worth as much then

Seen from the society’s point of view, it is more the *number* and *types* of individuals receiving a given benefit, which matters, and not whether it is a *specific* person. Hence, the idea that someone would like to consume now rather than in the future is not applicable to public goods, which can be enjoyed now *and* in the future. Also, the risk of one person dying before he or she gets the benefit is of no relevance if

this person is just 'exchanged' by another (as will be the case for a number of costs or benefit elements accruing over time). Any positive discount rate devalues future costs or benefits and this disadvantages future generations with respect to today's decisions. The logic of money – and in this respect the logic of discounting – may thus seem inappropriate when evaluating certain types of costs and benefits. This is especially the case for (long term) environmental impacts (Goklany, 2009; Næss, 2006).

The final problem with CBA to be mentioned here is that of social equity. This can be divided into three separate questions:

The first critique relates to the individual welfare measurements: When valuing costs and benefits often methods based on individuals' WTP are used. As people's *willingness* to pay, whether measured directly or inferred in some way, will be intimately linked with their ability to pay, the market can be seen as a system which advantages those most able to pay. Hence using the market, whether an actual market or a contrived one, tends to produce values that reflect the existing distribution of income (Ackerman & Heinzerling, 2002). This can be argued as an equity problem.

The second critique relates to the aggregation of individual welfare measures into one of social welfare: In its conventional form CBA is about aggregated (and un-weighted) costs and benefits and does not deal with the issue of how they are distributed – although this is of prime concern when considering equity. As long as the sum of benefits outweighs the sum of costs (no matter who or how few people get the benefits and who or how many people suffer the costs) the society as a whole is assumed to be better off.

Some argue that in principle the CBA does not presuppose that individuals are treated anonymously – that is with equal weight in the aggregation of individual welfare into a measure of social welfare. In theory, one could aggregate individual welfare measures in a way (i.e. with weights) reflecting relevant equity concerns. However, as there is no established 'right' with regard to equity in the distribution of individual welfare, where would a decision maker get the needed weights? No unique set of 'equity weights' exists, and therefore anonymous aggregation has become the default in CBA.

The third critique is that although the method rests on the aggregation of individuals' WTP, no actual payment takes place and no actual redistribution of money results (Alcock & Powel, 2011). Hence, the socio-economic optimum resulting from the CBA could be argued on equity grounds as being somewhat hypothetical.

3 Investment criteria

Investment criteria are introduced below as they are main components of the CBA process, which is described in the following chapter. The description makes use of the following references (Leleur, 2000) and (DMT, 2003).

Transport infrastructure projects are characterised by having consequences which range over the years. Typically, a construction phase with net costs in the opening year will be replaced by net benefits, that due to a continuously increasing traffic will steadily grow in the following years. This is shown in Figure 3.1.

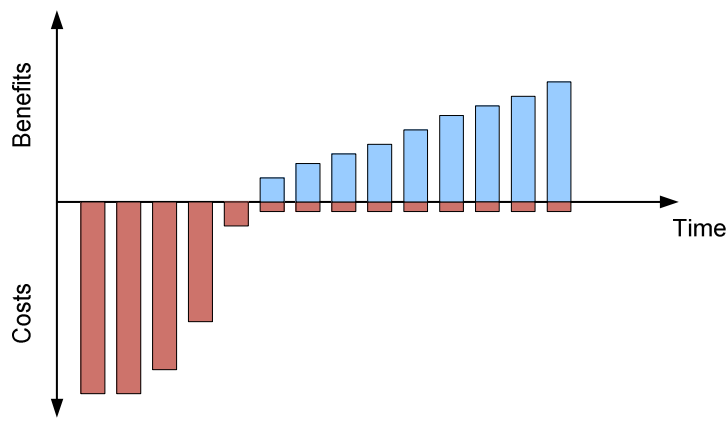


Figure 3.1: Development of costs (red) and benefits (blue) over the years

Different project types and sizes are characterised by differences in the development of the future benefits. However, economic index values exist which can aggregate streams of costs and benefits into a single value which reflects the profitability of the project. These indices are useful for socio-economic analysis but need to be selected in accordance with their valid applicability and applied based on the availability of data in the evaluation task at hand. At present, the index that is most applied is the net present value.

3.1 Net present value (NPV)

The calculation of the net present value (NPV) is carried out by the use of (3.1):

$$NPV = \sum_{t=0}^T \frac{B_t - C_t}{(1+r)^t} \quad (3.1)$$

- T: The calculation period of the project in years
- B_t : The amount of benefits in year t
- C_t : The amount of costs in year t
- r: The discount rate

For every project calculated, the streams of benefits and cost are aggregated into a single number, the NPV index value, which indicates from its actual size the profitability of the project or initiative. A minimum demand is that $NPV > 0$.

The principal content of the NPV calculation consist of the different time-dependent weights attached to the time-displaced benefits and costs by use of the so-called discount factor $(1+r)^{-t}$, where a fixed discount rate is normally applied with $r > 0$. The higher values of r and t , the lesser the added contribution from the discounted value, see Figure 3.2.

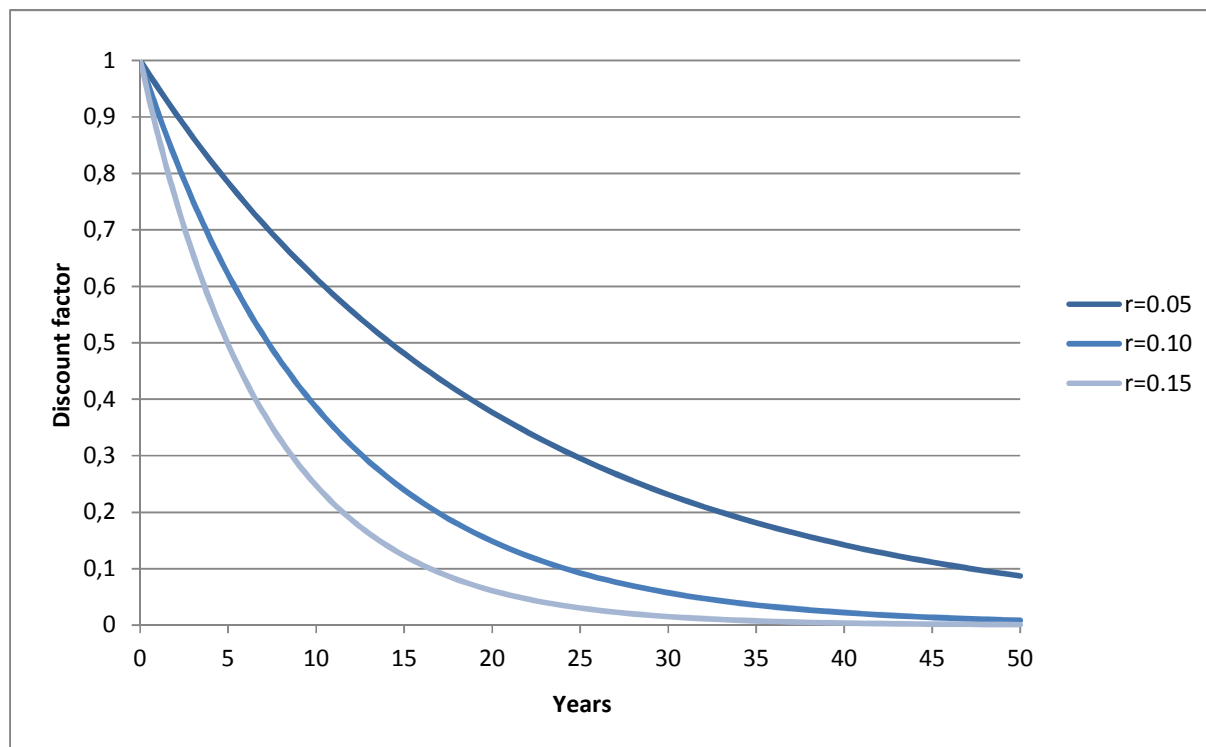


Figure 3.2: The discount factor $(1+r)^{-t}$ as a function of t and the discount rate r

The actual value of the calculation rate is an expression of the emphasis on benefits in the near future as compared with benefits in a more distant future. Due to the types of projects associated with the benefit types, a low rate will favour larger projects with a long project life, while a high rate will lead to a comparatively higher profitability of projects lesser in costs and size. In Denmark the discount rate has since May 2013 been 4 % for year 0-35, 3 % for year 36-70, and 2 % after year 70. The rate is constantly under revision tending to vary across Europe.

When conducting a NPV calculation, a base year must be determined for price level reference. No attention is paid to inflation, but account can be taken of forecast growth in real terms of some of the benefit components' unit prices.

The NPV index has been assessed to be the correct and most important among the investment criteria used for public investment decisions; other criteria that are important and currently used such as the

internal rate of return, can under certain conditions give results which may be inappropriate and sometimes in conflict with a NPV calculation.

3.2 Internal rate of return (IRR)

The purpose of the internal rate of return (IRR) is to determine the rate i , which balances the cost and benefit streams. The rate is calculated by the use of (3.2):

$$\sum_{t=0}^T (B_t - C_t) \cdot (1+i)^{-t} = 0 \quad (3.2)$$

T , B_t and C_t : As previously

i : The internal rate, IRR

The higher the rate i , the better the examined project. An advantage of this criterion is that a calculation rate is not needed as when calculating NPV. The IRR has often been used by the World Bank for infrastructure projects in developing countries. An uncertainty with the IRR method is that it is the solution to a polynomial equation with several roots, which cannot always easily be sorted out. Sometimes it can be in conflict with the NPV rule as illustrated in Figure 3.3 with an example of comparison between two projects A and B, with calculated IRR and NPV values.

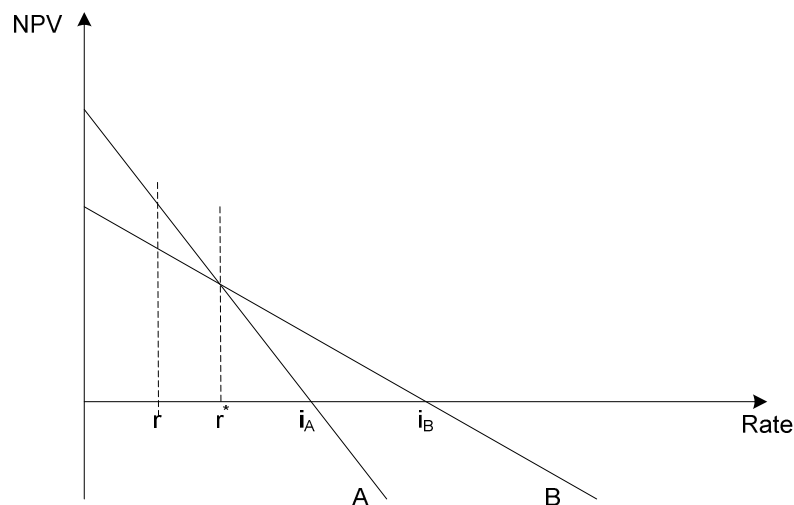


Figure 3.3: Comparison of two projects examined by use of the NPV and IRR criteria

When applying the IRR index, B should be preferred to A as $i_B > i_A$, while the opposite is the case when using the NPV index if a discount rate $r < r^*$ is adopted. The most correct solution would be to apply the NPV calculations, if agreement can be reached about the discount rate to be used.

3.3 Benefit/Cost rate (B/C-rate)

An index that has been used widely earlier is the so-called B/C-rate, calculated by the use of (3.3):

$$B/C = \frac{\sum_{t=0}^T \frac{B_t}{(1+r)^t}}{\sum_{t=0}^T \frac{C_t}{(1+r)^t}} \quad (3.3)$$

A minimum demand is that of $B/C > 1$. When applying the B/C-rate, it must be observed that the criterion calculates discounted benefits per discounted investment unit. Thus, if a comparison is carried out among a group of projects that differ in size and investment demand, the B/C-rate will not determine the project with the numerically largest net benefits as is the case with the NPV. On this basis, however, it is relevant to apply the B/C-rate in connection with priority studies under a budget. This is shown in the example in Table 3.1 with the ranking of 7 projects, A-G. For simplicity a project life of one year is used. The discount rate is set to be $r = 5\%$ and the budget is 5 investment units.

Table 3.1: Application of B/C-rate for project priority

Project	Construction cost	Benefits	NPV	B/C
A	5	10.50	5.0 (1)	2.0 (4)
B	1	3.15	2.0 (3)	3.0 (2)
C	1	4.20	3.0 (2)	4.0 (1)
D	1	2.63	1.5 (4)	2.5 (3)
E	1	3.15	2.0 (3)	3.0 (2)
F	1	2.63	1.5 (4)	2.5 (3)
G	1	3.15	2.0 (3)	3.0 (2)

It can be seen that with a budget of 5 the total NPV can be increased with 5.5 from 5 to 10.5 (= $3+2+2+1.5$) by applying the B/C-rate instead of the NPV-ranking.

When using the B/C-rate it must be noted that a negative benefit or dis-benefit does not equal a cost of the same magnitude, as numerator subtraction is not the same as denominator addition (for example: $(3-1)/3 = 0.67$ being different from $3/(3+1) = 0.75$). In a NPV calculation, however, it is not possible to discern a dis-benefit compared to a cost as it is the net benefit, which is discounted. For that reason, consistency is demanded when defining the benefit and cost elements to be used in a B/C-rate calculation. In connection with its priority studies, the Danish Road Directorate considers running maintenance costs as a dis-benefit, while major road repair works carried out over the project life are considered as a cost and are added to the initial construction costs. The reason that the laying of asphalt is seen as belonging to the cost-side is that the expenditures do not fall evenly year by year on a given stretch, but as separate investments after a number of years, for example every 10th year.

It should be noted that the Danish manual (DMT, 2003) makes use of an approach, which calculates the ratio between the NPV and the present value of the direct costs of the project. The rate then indicates the present value of the project per DKK from the public expenditures. The rate is calculated by the use of (3.4):

$$NPV / C_{pub} = \frac{NPV}{\sum_{t=0}^T \frac{C_{pub}}{(1+r)^t}} \quad (3.4)$$

C_{pub} is the public expenditures and consists of the construction costs, the maintenance costs, and the tax revenue in a conventional appraisal. In order for a project to be feasible the rate should be positive, i.e. larger than 0.

3.4 Types of investment decisions

The described, economic indices can be applied to different types of investment decisions. A basic type of decision is whether a project is feasible at all. Another type of decision may concern which project should be preferred for construction among a set of alternatives, while a third type of decision – the prioritisation problem – consists of the selection of a minor group of projects from a larger project pool. These decisions are often affected by possible interdependencies among the projects and by the probable limits of an investment budget for the planning period.

With regard to interdependencies, projects not in the vicinity of each other, will as a general rule, be interdependent, but may be dependent to some extent as parts of a long distance national or international route of importance. Projects sharing hinterlands or complementing each other in a regional corridor or network must be examined accordingly. The situation with project interdependence should be addressed in connection with the transport modelling that is carried out to make traffic forecasts for use in the economic analysis. Specifically, it must be examined how different benefit types are increased or decreased when a project enter into a combination with other projects.

Table 3.2: Types of investment decision as a decision tree

Decision type	Project dependence	Budget constraint	Criterion
Acceptance of project			NPV > 0
One of several projects			Max. NPV
Few of many projects from a pool	Independent	Yes	Rank by use of B/C-rate > 1
		No	Rank by use of NPV > 0
	Dependent	Yes	Find feasible set: max. NPV
		No	Find possible set: max. NPV

Another question to examine is whether displacement in time should be taken into account in the shape of staged-construction. This contributes to the number of possible combinations, but could be a way to balance the available budget in a year-by-year programme. The question of which economic criterion to apply for which type of investment decision is schematically shown in Table 3.2.

3.5 Sensitivity analysis

Often, the parameters and forecasts in a CBA will be associated with some degree of uncertainty. Forecasts concern future developments, and as the future is never completely certain, such forecasts are inherently uncertain. Furthermore, some parameters like the value of time, the value of life, or the price of regional pollution have been estimated in various ways – because the ‘true’ values are unknown – implying that they are, by nature, uncertain. Therefore it is of relevance to analyse how small changes in estimates and forecasts will affect the conclusions of the CBA. This is called sensitivity analysis.

A sensitivity analysis may give important information. If the NPV is not really affected by changes in a parameter or a forecast, this tells the planner (and the decision maker) that the conclusion is rather robust towards the uncertainty associated with that parameter or forecast. On the other hand, if the NPV is greatly affected by a small change in a parameter or a forecast, this indicates that the choice of estimate should be made based on careful considerations and analyses. Furthermore, the resulting uncertainty in the conclusions should be presented to the decision maker.

4 The CBA process

It is a characteristic of socio-economic analysis that there need not be (in fact, only seldom is) agreement between the cost and benefit elements relevant to a private company and those relevant to the society as a whole. While a private company will most likely in-calculate only its own costs and benefits, it is necessary in a socio-economic analysis to include also costs and benefits to other parts of society – so-called external effects (or externalities).

Example: A private company considers opening a new factory. The financial manager makes a financial analysis, which shows that the investment costs of a new factory will be more than recovered by the expected increase in sales. Hence, the company proceeds with the plans. However, the new factory will have consequences for neighbours in the area. They will perhaps endure noise, smell or smoke nuisances from the new factory. These are social costs, which are not accounted for in the financial manager's analysis, but which would be included in a social CBA – perhaps giving that building a new factory is not a social welfare improvement.

Society as a whole does not have unlimited resources, hence a prioritising is needed between individual project alternatives. Decision makers have to choose sometimes between several projects before a new road is built or some new infrastructure can be developed. In this process the CBA helps to decide which project alternative that benefits the society the most. This is, however, not the same as saying that the project that brings the best overall benefit to society has to be implemented. The decisions made from stakeholders and decision makers in general are often subjected to political agendas and investors' preferences. Hereby it is necessary to stress that a CBA is only functioning as a decision support tool in the overall decision process. The Danish Manual states that: '*... it is of course easier to achieve political accept of a project if the socio-economic rate of return is high – but it may not lead to implementation.*' (DMT, 2003 p. 12).

The Danish Ministry of Transport and the Danish Road Directorate has conducted CBA on road infrastructure projects for a long time (Leleur, 2000). The socio-economic manual from 2003 has developed a general framework for socio-economic analyses for all modes. The aim is to identify identical measures and procedures when evaluating transport projects and enabling analysts and modellers to make identical analyses.

Figure 4.1 presents an overview of the flow in appraising road infrastructure projects in Denmark. By implementing this step-wise procedure the socio-economic analysis becomes more comprehensive both towards politicians but also towards the analysts or modellers carrying out the analysis.

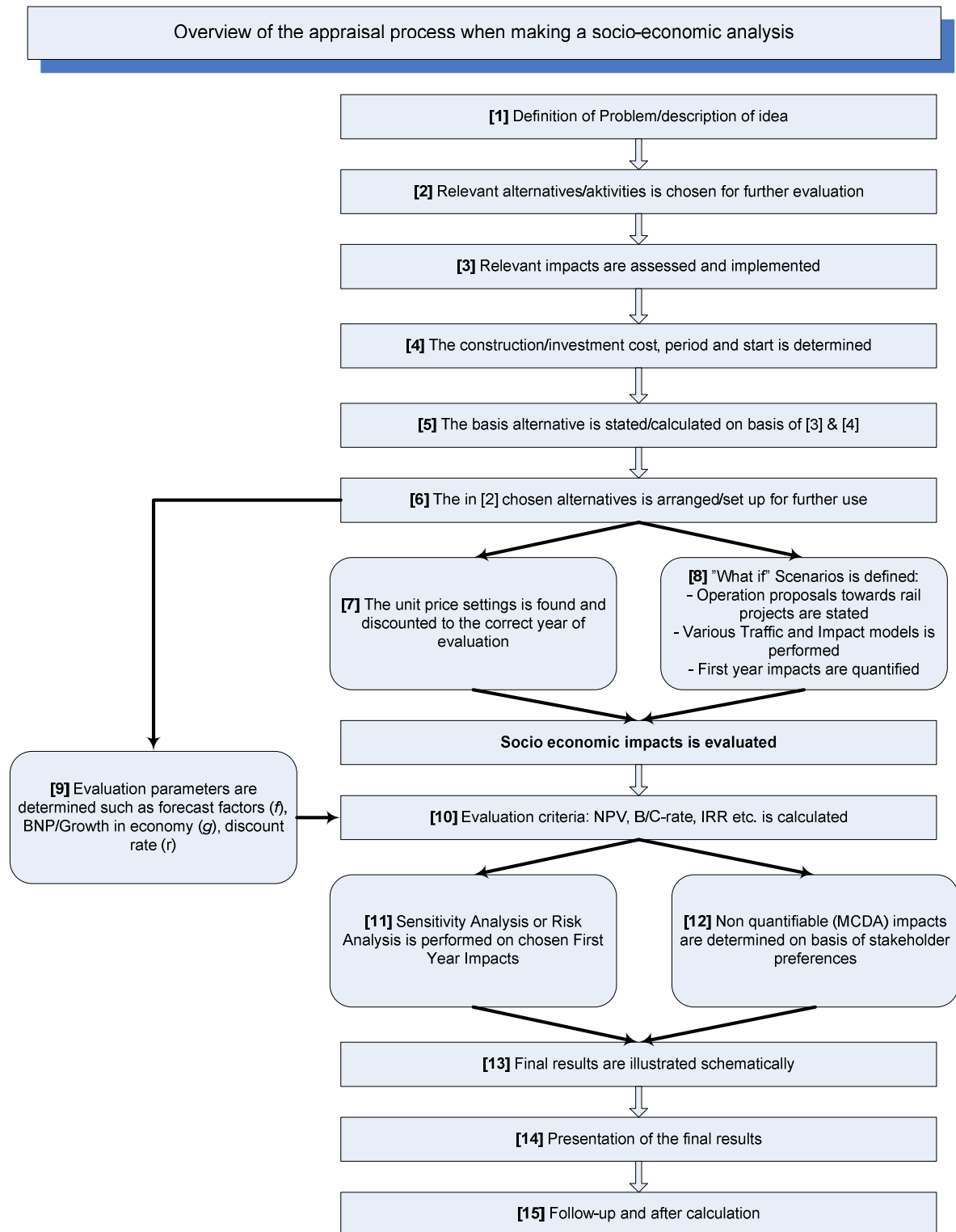


Figure 4.1: Overview of the socio-economic analysis (DMT, 2003)

The above mentioned flowchart illustrates the examination process of e.g. a road infrastructure project. Such a thorough investigation for each project is of course not always applicable. In the following emphasis is on the 'must do' processes when making socio-economic analysis and hereby CBA. A small selection of traditional impacts and parameters associated with a CBA in the transport area is shown in Table 4.1 and Table 4.2. The following section will elaborate on the impacts and give a more detailed description.

The impacts are merely guidelines and should be treated specifically for each specific project (DMT, 2003). The Danish unit values assigned to each impact can be seen in the key figure catalogue published by the Danish Ministry of Transport (DMT, 2010). This catalogue is regularly updated and can found at the homepage of DTU Transport's Modelcenter (look for 'Transportøkonomiske enhedspriser').

Table 4.1: Overview of primary impacts for CBA of transport projects in Denmark

Primary impacts	Description
Construction costs	The total investment for the project discounted to the calculation year.
Nuisance related to construction	Covers the problem during the construction period. Herein lies traffic or extra noise problems for the residents near the construction site etc.
Maintenance costs	Net change in maintenance costs of the project. This impact is traditionally considered a dis-benefit toward society.
Scrap/terminal value	The monetary value of the project at the end of the evaluation period. Normally, this impact is calculated as the total construction costs discounted to the opening year from the last year of the calculation period (traditionally 50 years). The reasoning for having a scrap value equal to the original investment lies in the maintenance of the project.
Travel time savings (TTS)	TTS are valued depending on the type of trips (home related, business related etc.) and the type of vehicle e.g. passenger cars, heavy vehicles etc. For air transportation four main types of time savings are considered: Primary flying time (in flight time), waiting time (normally caused by delayed time), changing time (between aircrafts) and hidden waiting time (scheduled time due to e.g. one flight per day).
Driving costs (DC)	Valued cost per driven or flying kilometre. Traditionally, this impact holds the cost for e.g. petrol, wearing of the roads, wearing of car/aircraft material etc.
Fees or taxes	Danish infrastructure investments are normally covered by the government via tax money. These taxes are, however, distorting the market as compared to a private company. By implementing both a tax distortion factor and a net taxation factor the gap between government financed and privately financed projects are closed.

Table 4.2: Overview of secondary (external) impacts for CBA of transport projects in Denmark

Secondary impacts	Description
Noise	The number of households subject to more than 55 dB (A) multiplied by an ancillary nuisance factor resulting in a so-called Noise Load Number – SBT (StøjBelastningsTal – in Danish)
Accidents	The difference in the number of mild injuries, severe injuries and killed compared to the before situation. Traditionally, these impacts are calculated on the basis of prior accident frequencies, road type and the Average Daily Traffic (ADT) on the road
Local air pollution	Net difference in emission covering locally pollutants such as NO _x , HC, SO ₂ , CO and small particles
Regional/global air pollution	Net difference in emission covering globally pollutants mainly affecting greenhouse and the ozone layer such as CO ₂

The CBA is to be carried out on real terms basis, meaning that all values throughout the appraisal period being based to a convenient recent year, such as year 2010 prices and values. So the CBA is conducted in a world free of inflation. However, if the prices of specific inputs or outputs are predicted to change relative to other prices these real price changes should be allowed for.

Care should be taken to ensure that project specific parameters such as the start year and investment period are considered for each project individually, so that the discounted costs and benefits can reflect differences on timing between projects. Note that NPV depends on the year, where it has been evaluated, whereas the B/C-rate is generally not transformed as this expression is ‘unit-less’.

For most infrastructure projects, the length of its service life will exceed the appraisal period. In these cases, it is acceptable to include in the benefits for the final year of the service period a residual value. This serves to capture any remaining net benefit that is in excess of the remaining user benefits over infrastructure maintenance and operating costs, up to the end of the technical life of the asset. As a minimum the scrap value of the technical asset should be included in the appraisal. The scrap value is calculated by including the investment costs as a benefit in the final year of the appraisal period. This value is then discounted back to the base year. This implies that the asset has the same value in the end of the appraisal period as in the beginning based on an assumption that the asset has been maintained during the period, so it all the time is fully functional.

In general, demand forecasts (prognosis) should be undertaken for a minimum of two years – the opening year (defined as the first full year of operation) and the design year which should be chosen taking into account of available macroeconomic forecasts and other data (typically around the 10th year of operation). The opening year is required to test that the project is worth undertaking now. The design year is required to secure that the design is appropriate for the forecast volume of traffic. Both are required in order to establish the benefit and cost streams over the appraisal period.

4.1 The discount (or calculation) rate

The discount rate is used to compare all benefits and dis-benefits (associated with a project) over time thereby making the value of present and future impacts comparable. Many things are relevant to consider when setting an interest rate to be used for public projects. Ideally seen a rate of interest is the interest you could achieve by investing in other projects, but at the same time it is an expression for an 'impatience factor' saying that you rather want your profit today than tomorrow (and rather want your expenses tomorrow than today). However, it is not so simple to determine what the most appropriate level of the interest rate is as no common well-defined rate exists that expresses the societal most optimal rate of interest.

Economic theory cannot provide a clear answer on which societal discount rate should be chosen – neither generally nor for infrastructure projects, which are characterised by a long service life. However, some viewpoints exist on how the present and the future can be compared. A possible choice is to use the society's (the consumer's) time preference rate expressed as a yearly rate of return. The time preference rate is relevant when an investment suppresses private (or public) consumption by e.g. drawing on savings in the society. The time preference rate indicates how much the consumer will demand or expect by refraining from consumption now and instead postponing it to later. For some this rate can be negative if there is security that the savings are available. For others (e.g. younger people) the rate can be very high. Typically it is assumed to be positive.

In Denmark the discount rate is determined by the Ministry of Finance and is at present time (in February 2014) 4 % for year 0-35, 3 % for year 36-70, and 2 % after year 70. The rate is constantly under revision and tends to vary across Europe. When addressing cross-national projects within the European Union it has been recommended to use 3 % (HEATCO, 2004), but the Guide to Cost Benefit Analysis of Investment Projects (EC, 2008) now applies a discount rate on 5.5 %.

4.2 Tax distortion

As mentioned a consistent treatment of taxes is needed when examining public projects.

As, in principle, a CBA of a public project in-calculates all effects on society, it may be (and often is the case) that the project is profitable from society's point of view, but results in a financial deficit on the national (or local authority) budget. In such a case, the project must be fully or partly financed through tax income.

However, taxes lead to distortion of economic activities. As an example the income tax leads to lower work supply than would be the case without it. The following example is from (DMT, 2003):

Example: Assume that person A is willing to do a job for person B for the amount of 100 DKK, and that person B values this job at 110 DKK. This means that both person A and person B would benefit of engaging into business. However, if person A is taxed 50 % he would only receive 55 DKK of the 110 DKK B is willing to pay. This means that the work will not be done, and the potential surplus of 10 DKK is not realised.

The example shows that society loses 10 DKK – the so-called ‘dead weight loss’.

This example illustrates that if public projects are financed through taxes there will be a loss due to the way of funding. Currently, the loss is set to 0.2 DKK per DKK financed through taxes (DMT, 2010).

In practical CBA this means that one has to calculate first all the financial impacts (costs as well as benefits) on the national (or local authority) budget. These costs and benefits are discounted by use of the social discount rate. If the net present value is negative, the project needs to be (partly) financed through taxes, and the negative value equals the tax funding. This tax funding should then be multiplied with a *tax factor* expressing its marginal costs – that is (as indicated above) a factor of 1.2.

The Danish Ministry of Finance (DMF, 1999) mentions that as an alternative to using a tax factor one can use a social discount rate of 6 % instead of the recommended 5 %. This rule-of thumb is applicable *only* for projects with a time horizon of more than 20 years.

4.3 Net taxation factor

All costs in the appraisal (except taxes) must be multiplied with the net taxation factor in order to make sure that all costs are calculated as user prices (market prices). The net taxation factor is calculated as the ratio between the gross domestic product (GDP) and the gross factor income (GFI), and thus describes the pressure from indirect taxes in the socio-economy. Hence, when converting from factor prices to market prices the net taxation factor describes the average difference between factor- and market prices. The net taxation factor is currently 17.1 % in Denmark.

4.4 Calculation period

The calculation period should ideally correspond to the life time of the project. However, infrastructure projects do not necessarily decay as they are continuously maintained and therefore a relevant time frame for the calculations must be decided.

For large infrastructure projects it is recommended to use a calculation period equal to 50 years, while more operation related projects typically are assigned with a shorter calculation period. E.g. it is not relevant to use a calculation period that is longer than the actual life time for new machinery when considering investing in new trains, unless one tries to estimate the optimal life time for a repeated investment.

A special element, which should be considered when operating with a time frame shorter than life time of the investment, is the scrap value of the project, i.e. the value of the investment at the termination of the calculation period.

4.5 The base alternative

The base alternative is the scenario where the planned project(s) is not realised, often called a ‘do-minimum’-scenario. It means that the base alternative, like the planned project(s), can also include

construction costs, operating costs and externalities. It could for instance be construction costs in connection with the creation of more capacity on existing roads and railways, e.g. in the form of more tracks with the corresponding consequences for both the operating and maintenance costs and the externalities.

4.6 Choice of year for the price level and opening year

It is necessary to determine a price level year in which the various costs and benefits can be assessed. Sometimes the construction costs are available at the current year's level. If this is not the case the previous year is applied. It is very important to understand that this is what the economists call a 'numeraire', that is the money-measurement stick used for 'pricing' of different 'amounts'.

The most optimal year for an evaluation calculation is the opening year of the project. The chosen year of the socio-economic calculation will normally be a number of years later than the price level year dependent on the project and its construction period.

4.7 Construction - and maintenance costs

The construction costs are traditionally the impact used as a standard of reference in the further socio-economic analysis. The politicians and other decision makers make their decision on basis of this parameter. The construction costs will generally be realised over a number of years which is made by discounting the construction cost into the calculation year. The operating and maintenance costs are the difference between the base scenario and the new alternative suggested. The estimates for the construction costs and maintenance costs are made by using market prices and engineering cost calculations. The maintenance costs can be obtained from accounts of precious expenses, which indicate, for example, the split between traffic dependent and non-dependent costs (Leleur, 2000).

The construction costs are usually spread over several years. A distribution of the construction costs may look like in Table 4.3.

Table 4.3: Time dependent distribution of the construction costs

Year	-5	-4	-3	-2	-1	Total
Percentage of construction costs	15 %	20 %	25 %	30 %	10 %	100 %

4.8 Travel time savings

The travel time savings depend on the difference between the flow in the before-network and the after-network, where the latter is the changed network, for example in a most simple situation a road through a town supplemented with a by-pass around the town. Even in simple situations it is relevant to make use of a traffic model to forecast the behaviour aspects; in more complicated situations where the building of new network links influence a large part of the network socio-economic analysis is completely

dependent on making use of traffic models. Traffic models are not treated in this compendium but overall it will be assumed that relevant outputs are available from such models.

In present day travel time savings and driving costs are often presented as output from runs with a traffic model suitable for the traffic planning problem at hand.

4.9 Driving costs

Driving costs consist of cost related to:

- Fuel
- Oil
- Tires
- Maintenance of vehicle
- Depreciation
- Insurance

Several models for calculating driving costs exist and they vary in complexity. To assess the impact of a project on driving costs, unit cost in DKK/km determined by the Danish Road Directorate is often used. However, the driving costs are dependent on the speed which may be included in the calculations. Often a fixed valued cost per kilometre is used.

5 Case example I – construction of a new road

In order to illustrate the CBA process a theoretical case study is presented based on an example from the Danish Road Directorate (DMT, 2004). In the study a new motorway, which is supposed to replace an existing main road between two major cities, is examined. The case goes through the main elements in a typical socio-economic appraisal, where the planning process is well under way, the alignment of the road is known, etc., and it is for this reason possible to make use of traffic- and impact models being available.

The background and purpose of the road project is mainly a wish to reduce travel time and improve the traffic safety in the area.

5.1 Assumptions

In the case study we will consider the construction of a 4-track motorway as the only alternative to the current situation (the main proposal). In principle we will assume that the alternative is not to build anything at all. If the existing road is in such a bad condition that some form of construction or maintenance work is needed, then the relevant alternative would be such an improvement unless a closure of the road would be more beneficial.

It is assumed that the construction work will begin in 2015 and that the road will open in 2020 with a calculation period of 50 years. This implies that impacts will be estimated for each year until 2069. The opening year (2020) is set to year 0 in the CBA calculations, i.e. the base year for the discounting.

All prices are in 2010-level, which means that unit prices etc. can be taken directly from the Key Figure Catalogue (at the time of the writing of this material in January 2013 – check the current price level year before starting a calculation).

In principle the impacts should be calculated for each of the 50 years in the calculation period using traffic- and impact models as most of the elements are expected to change during the life time of the road. However, this will be a very large and time consuming task, so most often you will choose to only make a few calculations (e.g. for the opening year and 50 years later). Doing this you can easily get an idea about the intermediate years. In the presented case it is assumed that the models have calculated the impacts for the opening year, while the following developments are treated using simple forecast factors.

It is assumed that a realistic traffic growth factor has been used until the opening year 2020. No traffic forecast exists that covers all 50 years in the calculation period as it is impossible to predict how e.g. the technological development will influence the traffic in the far future. This problem can be handled in several ways, but in this case an increasing traffic on 1.5 % per year is chosen for the first 20 years after the opening after which the traffic is assumed to be constant. This is an approach often used by the Danish Road Directorate.

The calculations represent a sort of mean value, which means that it is assumed that the probability of a price or impact being higher than estimated is the same as the probability of the price or impact being lower. Uncertainty is therefore not included in either the estimates of the elements in the appraisal or in the final results. Some simple sensitivity analysis is, however, made use of in the end of this example.

In a socio-economic appraisal an attempt is made to quantify the costs and benefits of a given project. A number of impacts are, however, difficult to quantify as they can be of a more strategic character or difficult to measure. This could e.g. be impacts such as driver comfort, flora and fauna, natural habitats etc. Even though such impacts are of significant importance they are not included in the appraisal due to lack of quantitative data and unit prices.

5.2 Elements in the appraisal

5.2.1 Construction and maintenance costs

The actual construction costs of the road are assumed to be 1.5 billion DKK in 2010 prices including expenses for expropriations etc. The construction period is set to 5 years starting in 2015 and the costs are assumed to be distributed linearly over the period. Including the net taxation factor on 17.1 % the amount will be approximately 1.76 billion DKK. With a discount rate on 5 % (the standard at the time of writing this example in January 2013) the present value of the investments in 2020 will be approximately 2,0 billion DKK (minus) (observe that this is the value of the investment as it will be in 2020 but estimated in 2010 prices). The calculations are depicted in Table 5.1

Table 5.1: Calculation of construction costs (2010-price level)

Construction period	5 years						
Discount rate	5%						
Net taxation factor	17.1%						
Actual investment (mDKK)	-1,500						
Incl. net taxation factor (mDKK)	-1,757						
Year	-5	-4	-3	-2	-1	0	Total (mDKK)
Before discounting	-351	-351	-351	-351	-351		-1,757
After discounting	-448	-427	-407	-387	-369		-2,038

The increase in maintenance costs (compared to the present situation) are set to 10 million DKK per year (after the opening year). Including the net taxation factor the cost is approximately 11.7 million per year. The amount covers both running maintenance and the more comprehensive renovation works that need to be carried out at regular intervals in order for the road to be of a satisfactory standard during the whole period. The maintenance costs are distributed equally on each year. The project will most likely cause lower maintenance costs on the existing road due to lower traffic volumes. This is assumed to be included in the total amount.

Table 5.2 depicts the total maintenance and construction costs for the case example.

Table 5.2: Costs for construction and maintenance including net taxation factor, market prices (2010-price level)

Year	-5	-4	-3	-2	-1	0	1	2	...	48	49
Construction costs	-351	-351	-351	-351	-351						
Maintenance costs						-11.7	-11.7	-11.7	...	-11.7	-11.7
Total	-351	-351	-351	-351	-351	-11.7	-11.7	-11.7	...	-11.7	-11.7
Discounted to base year	-448	-427	-407	-387	-369	-11.7	-11.1	-10.6	...	-1.1	-1.1

As mentioned the calculation period is set to 50 years after opening. If the road is maintained appropriately it is still expected to be of a high value at the end of the calculation period. This value is assumed to be the same as the construction costs (1.76 billion DKK) in year 2069. Converted to present value in 2020 this scrap value corresponds to 161 million DKK. The calculation is shown below:

$$\text{Scrap value} = \frac{\text{Construction cost}}{(1 + r)^t} = \frac{1,757 \text{ million DKK}}{(1 + 0.05)^{49}} = 161 \text{ million DKK}$$

t is set to 49 as we are discounting from the last year in the calculation period (year 49) to the calculation year (year 0).

5.2.2 Disruption due to construction

During the construction phase the public will often be affected to some extent. The construction works can e.g. result in increased noise for the citizens nearby, or the traffic can be affected on the existing roads. Problems can especially occur if an existing road is being upgraded to a motorway without closing the road. This means that the traffic flow must be maintained while working on the road. It is, however, possible to reduce the problems by e.g. only working during night-time or similarly. This will create some extra expenses, which it is possible to include in a CBA. It is assumed that this will not be an issue for the case example, i.e. the impact is not included in the calculations.

5.2.3 User impacts

The consumer surplus as a result of the new road project is calculated on the basis of the changes in the generalised travel costs, which consist of driving costs and travel time savings. In principle all types of road users should be included in the calculation of the surplus. In the current case users transferred from other modes such as trains, busses or bikes are treated in the same way as new car trips. Moreover, the project could possibly result in advantages for busses and their passengers, but only if the relevant operators are affected. This is, however, not included in the calculations.

Traffic models

It is assumed that a traffic model has been used which can provide the necessary information, and among other things model all relevant transport modes. A traffic model will often be linked to a specific geographical area (e.g. Denmark or a part of a country) that is divided into zones. The result of the model will then be the traffic between the zones (the Origin-Destination (OD) matrices).

Normally we operate with existing and other users, where the latter consist of three sub-groups:

- Existing users (possible change in route choice)
- Generated users due to changed destinations
- Generated users due to modal shift
- New users

From the OD-matrices calculated by the traffic model it is not possible to distinguish between the last three types (from now on denoted 'other' users), but as these are treated equally in the calculations the problem is insignificant. The model calculations partly consist of a basis scenario (without the project), and of a scenario where the project has been modelled. All impacts are calculated for the opening year (2020).

Passenger cars, vans and heavy vehicles

The 'existing' users are those that – according to the model – do not change behaviour, but still are affected by the project in respect of changes in driving distance or travel time used. In this particular case the model shows that the existing passenger car users drive approximately 7 million kilometres extra in the opening year (compared to the base scenario), but at the same time they save approximately 700,000 hours of travel time. Using unit prices for driving costs and travel time savings respectively it is possible to calculate the first year impact for these users.

For the 'other' passenger car users the model calculations show a change on 2,600 trips as a result of the project. 120 of these are transferred from public transport modes (shown as a decrease in public transport passengers), 650 are newly generated trips, and 1,830 trips have changed destinations. As mentioned above, these three categories will be treated in the same way in the following calculations, i.e. in accordance with the rule-of-a-half, see Section 2.1.

The calculations use the unit prices for one driven kilometre and for one hour spent. The marginal driving cost in market prices for passenger cars is 1.61 DKK per kilometre (2010 prices). The price includes costs such as fuel, vehicle maintenance, depreciation, and taxes. The time value for an average person is 95 DKK per hour (2010 prices) including net taxation factor for the industry segment. This value is calculated on the basis of a standard distribution between trip purposes for cars – in some cases the model or the data available makes it possible to calculate a more case specific value.

Due to the extra driven kilometres in the network the existing users will experience a negative benefit on approximately 11.3 million DKK per year (7 million km x 1.61 DKK/km). The changes in travel time will on the other hand result in a positive benefit on 66.5 million DKK (700,000 h x 95 DKK/h). This implies a net

benefit on approximately 55.2 million DKK. The net benefit for the 'other' users is calculated to approximately 3 million DKK.

Using the same procedure – but based on other unit prices – it is possible to calculate the benefits for vans and heavy vehicles. For existing vans an increase on 1.4 million kilometres and a saving of 70,000 hours is calculated. The corresponding numbers for heavy vehicles are an increase on 600,000 kilometres and a decrease of 30,000 hours. It is assumed that all traffic with vans and heavy vehicles are with business purposes, which means that the marginal driving costs (DC) and travel time savings (TTS) are inclusive of the net taxation factor. For vans and heavy vehicles the net benefit for the 'other' users is calculated to 1.1 million DKK and 0.7 million DKK. Table 5.3 summarises the calculations for the user impacts.

Table 5.3: User impacts in 2020 (2010 prices)

	Extra km 1,000	Tme saved 1,000 h	Unit prices		DC 1,000 DKK	TTS 1,000 DKK	Impact 1,000 DKK
			DKK/km	DKK/h			
Passenger cars							
Existing	7,000	-700	-1.61	-95	-11,270	66,500	55,230
Other							3,000
Total							58,230
Vans							
Existing	1,400	-70	-1.84	-297	-2,576	20,790	18,214
Other							1,100
Total							19,314
Heavy vehicles							
Existing	600	-30	-3.69	-411	-2,214	12,330	10,116
Other							700
Total							10,816
Total impact							88,360

As depicted in Table 5.3 the impacts for the existing traffic have the largest contribution. This is expected as the number of 'other' users in most cases will be marginal to the number of existing users.

Saved congestion

When the traffic on a road becomes close to the road's capacity limit problems with queues, low speed and delays will occur. This is a special issue in the traffic model as low speed on the road can lead to different changes in the users' behaviour, e.g. with regard to route choice, mode choice, or when to do the trip. The changes in behaviour can result in higher speed on the road, which then again will cause new conditions for the users. Thus it can be necessary to run the models several times before a state of equilibrium is reached.

Research has shown that users are willing to pay more to avoid congestion than the value for travel time. This is based on the fact that it is difficult to predict how long a trip will last, and that you need to leave

the origin early on in order not to be late for an appointment or similar. The value of saved congestion is set to 150 % of the value for normal travel time. The calculation is carried out by comparing the total number of hours spent on queue driving in the before and after situation for each mode.

Saved congestion can for some projects represent a very large part of the user impacts; however, it is assumed that no significant congestion problems exist for the case example.

Forecasting user impacts

The traffic is assumed to increase with 1.5 % per year in the first 20 years after opening regardless of whether the project will be carried out or not. After 20 years the traffic is assumed to remain constant. It is reasonable to assume as an approximation that the marginal impact will follow this increase, i.e. the user impact will increase with 1.5 % the first 20 years after 2020. Furthermore, the value of time for persons is assumed to follow the economic development, which means that the price is forecasted with 1.8 % per year (according to the prognosis from the Ministry of Finance). It is, however, more complicated to estimate if the same will be the case for vans and heavy vehicles (business related traffic), and as a consequence of this it is assumed that these prices will not develop over time.

5.2.4 Externalities

The project has a number of external impacts on the society, which also have to be accounted for in the socio-economic appraisal. In the calculations for this case study we will consider externalities in form of changes in number of accidents, noise and air pollution. Impacts such as barrier and perceived risk are in some cases included in the appraisal as well, but these are not accounted for here. Most of the impacts that cannot directly be converted into monetary units – such as the value of natural habitats influenced by the project, or regional economic development due to the project – are also externalities.

One could argue that the unit prices for the impacts that are based on the WTP principle (e.g. noise, air pollution, and accidents) should be forecasted using the economic development – as is the case for the time values. It is, however, chosen not to do so in this case example.

Accidents

The costs related to accidents can be divided into two parts: the costs for the user (including loss in welfare), and the costs for the society as a whole (costs for treatments, loss in production, etc.). The users' risk of accidents should in principle be a part of the calculation of user impacts that is included as a component of the generalised costs together with travel time and driving costs; however, it is very complicated to calculate the risk of accidents for each trip or pair of zones. Thus the accident costs are solely calculated as an externality.

The unit price for an average accident for a person is set to approximately 2.5 million DKK (2010 prices). This price includes the users' loss in welfare due to the injury. According to the model calculations the case project will result in a number of 14.3 saved accidents per year. This results in a net benefit on approximately 35.1 million DKK in 2020.

The increase in traffic will result in larger savings in the years after the opening year, but at the same time we can assume that safer cars and other safety initiatives will result in fewer accidents. Thus the project's influence on the number of accidents is assumed to remain constant in the calculation period.

Air pollution and climate

The air pollution consists of a number of substances. Each of these has either directly, negative impacts on humans' health or contribute in other ways to costs to the society. These impacts – and thus costs – depend on where the emissions take place. For most types of emissions the costs are largest within urban areas. The current road project will move traffic from urban areas to rural areas, which results in a positive impact. However, the road will at the same time result in more driven kilometres, which counts on the negative side. The total consequences for the emissions, unit costs, and costs for each type of emission are thus negative. As depicted in Table 5.4 the project will cause a negative impact for air pollution on approximately 4.5 million DKK in 2020. In addition to this more CO₂ emissions will cause a negative climate impact on approximately 0.8 million DKK in 2020.

As mentioned earlier the traffic is assumed to increase with 1.5 % per year, but as the technology develops the total emissions from vehicles must be assumed to decrease over time. In the case we assume that the project's influence on CO₂ emissions remains constant, and that the negative impact associated with the other emissions decreases with 1 % per year in the first 20 years after which it remain constant.

Table 5.4: Air pollution and climate 2020 (2010 prices)

Air pollution					
	Number		Unit price		Impact 1,000 DKK
	Rural	Urban	Rural	Urban	
	Tonnes		DKK/kg		
SO ₂	5	-1	-187	-216	-719
No _x	100	-20	-48	-48	-3,840
HC	0.2	-0.1	-2	-3	-0.1
CO	1,200	-200	-0.01	-0.02	-5
Particles	1	-0.2	-218	-1,566	95
Total					-4,469
Climate					
	Number		Unit price		Impact 1,000 DKK
	Tonnes		DKK/kg		
CO ₂	6,000		-0.13		-780
Total					-5,249

Noise

Noise is estimated as a noise annoyance index (in Danish: *Støjbelastningstal* – SBT). This is calculated as the number of dwellings annoyed by noise weighted according to the extent of the annoyance. The noise is expected to decrease with 140 units as a result of the new motorway, as a large part of the traffic is moved to areas with fewer dwellings. The price for a noise annoyance unit is 22,301 DKK per year (2010 prices). This indicates that the impact associated with noise decreases with approximately 3.1 million DKK in 2020 (i.e. the impact is positive).

The development in the traffic after the opening year is not significant for the noise impact as the marginal impact of a single vehicle on a road with a lot of traffic is very minor. At the same time we assume a development related to more noise reducing road pavements and tires. Hence, it is assumed that the noise impact is constant through the calculation period.

5.2.5 Taxation

The tax collecting authorities are experiencing increasing costs regarding construction, operation and maintenance of the infrastructure. At the same time the state will experience an increase in the tax revenue from the increased traffic. The tax per driven kilometre is estimated to 0.79 DKK for passenger cars (2010 prices). The yearly change in driven kilometres is estimated to 35.5 million kilometres, thus the state's tax revenue will be increased with 28.2 million DKK per year.

However, the changes in the passenger car users' driving costs are affecting other sectors as well, which then again affects the state's tax revenue. If the money has been spent on other products the state will still gain value added taxes (VAT) and revenue from other taxes. The net taxation factor on 17.1% is used for the purpose of regulating this extra income as a result of lower consumption in other sectors. Thus the passenger car users' total extra driving costs is approximately 57.2 million DKK in 2020 (35.5 million km x 1.61 DKK/km including tax). The state is assumed to lose 17.1 % of this amount before tax ($57.2 / 1.171 \times 0.171$), which is 8.4 million DKK in form of a lower tax revenue from other sectors. The states net tax revenue will thus be (28.2 – 8.4) approximately 19.8 million DKK in 2020.

The state will obtain the full tax revenue for vans and heavy vehicles as this only concerns business related trips. The tax per driven kilometre in vans and heavy vehicles is 0.26 and 0.92 DKK/km respectively, and in addition to this there is a time dependent tax on 6 and 7 DKK/hour respectively. Thus the state's tax revenue from vans and heavy vehicles are expected to be increased with approximately 380.000 DKK per year as a result of the project.

Totally there will be an extra tax related income on approximately 20.2 million DKK in 2020. Converted into market prices that is 23.7 million DKK. The revenue is expected to increase with 1.5 % per year for the first 20 years after opening after which they are assumed to be constant.

5.2.6 Distortion and the treasury

The tax collecting authorities' extra expenses need to be financed through extra taxes. A welfare loss is connected to this collection of taxes, which is denoted distortion loss. The public expenses consist of costs for construction and maintenance plus income from taxes. In principle changes in other impacts (e.g. accidents, pollution and noise) can also be of influence for the public expenses, but this is not included in this case example. The scrap value of the road in year 2069 is not included in this as it (normally) is not possible for the state to sell the road after the end of service life and thereby use the amount for financing other expenses.

The Danish Ministry of Finance has set the distortion loss to be 20 % of the net expenses, which gives the development in Table 5.5.

Table 5.5: Treasury and tax distortion

Treasury (direct impact i.e. factor prices)	Year										
	-5	-4	-3	-2	-1	0	1	2	....	48	49
Construction costs	-300	-300	-300	-300	-300						
Maintenance costs						-10	-10	-10	....	-10	-10
Tax revenue						23.7	24.1	24.4	....	31.4	31.4
Total	-300	-300	-300	-300	-300	13.7	14.1	14.4	....	21.4	21.4
Tax distortion											
	-60	-60	-60	-60	-60	2.7	2.8	2.9	....	4.3	4.3

Note that the tax distortion is calculated from costs/incomes exclusive the net taxation factor (factor prices).

5.3 The total socio-economic appraisal

The total socio-economic appraisal includes all the impacts that are converted into monetary values and discounted to year 0 (in this case the opening year 2020). The distribution of costs and benefits over 50 years and the present values of these are illustrated in Table 5.6.

Table 5.6: Basic calculation (million DKK) in market prices

Year	2020	2015	2016	2017	2018	2019	2020	2021	2022	....	2068	2069
State												
Construction	-2,038	-351	-351	-351	-351	-351	0.0	0.0	0.0	....	0.0	0.0
Scrap value	161									....		1,756.5
Maintenance	-224						-11.7	-11.7	-11.7	....	-11.7	-11.7
Tax revenue	637						27.8	28.2	28.6	....	36.8	36.8
Total	-1,464	-351	-351	-351	-351	-351	16.1	16.5	16.9	....	25.1	1,785.1
Distortion loss	-278	-60	-60	-60	-60	-60	2.7	2.8	2.9	....	4.3	4.3
Users												
Passenger cars	2,018						58.2	60.2	62.2	....	280.2	289.5
Vans	444						19.3	19.6	19.9	....	25.6	25.6
Heavy vehicles	248						10.8	11.0	11.1	....	14.4	14.4
Total	2,709						88.4	90.7	93.2	....	117.2	117.2
Externalities												
Accidents	673						35.1	35.1	35.1	....	35.1	35.1
Noise	59						3.1	3.1	3.1	....	3.1	3.1
Air pollution	-76						-4.5	-4.4	-4.4	....	-3.7	-3.7
Climate	-15						-0.8	-0.8	-0.8	....	-0.8	-0.8
Total	641						33.0	33.0	33.0	....	33.7	33.7
NPV	1,447	-411	-411	-411	-411	-411	140.1	143.0	146.0	....	180.4	1,940.4
IRR	7.6%											
NPV/C_{pub}	0.89											

The results of the basic calculation show a NPV on approximately 1.5 billion DKK, which indicates a socio-economic very feasible project. The internal rate of return on 7.6 % is larger than the calculation rate (or discount rate) on 5 %, and the NPV/C_{pub}-rate on 0.89 is positive, which both also indicates a socio-economic feasible project. This rate is especially useful as an investment criterion when several projects or alternatives need to be evaluated with the purpose of determining how to use the (normally limited) budget in the most effective way.

5.4 Uncertainty

In the socio-economic calculations of the project a lot of assumptions have been made which influence the final result. Thus when conducting a socio-economic appraisal, it is also important to address the various uncertainties associated with the assumptions. Such sensitivities should be implemented systematically in the appraisal in order to identify the critical assumptions.

In any project uncertainties will be associated to the prices and impacts included. However, in the current case it has been chosen not to attempt to describe the uncertainty associated with each element and total result of the appraisal, but instead to carry out some sensitivity analyses.

The two largest entries in the appraisal are the construction costs and the user impacts. Even in a phase where the construction is ready to commence and all details are settled uncertainties will still be associated with the costs. There will always be a risk of something happening, which have not been predicted. In the preliminary phase the uncertainties are even larger as the full magnitude of the project is often still unknown. If the construction costs for the case project is changed from 1.5 to 1.2 billion DKK the IRR is 8.8 % and the project is even more feasible. The construction costs have to be changed to 2.8 billion in order to achieve an IRR below 5 %, which indicates an infeasible project.

Most of the user impacts in this case are caused by the benefits the users on the existing road can achieve as a result of the new motorway. The uncertainties associated with these calculations are assumed to be relatively small as the project is rather far in the decision making phase. If the user benefits are increased with 10 % the IRR is 8.0 %, but if we assume that the user benefits are 50 % lower than estimated the IRR is 5.5 %. This indicates that the project is rather robust to changes in the assumptions.

Saved accidents are the largest entry in the externalities. Uncertainty can be related to the calculation method and to the fact that the number is quite low. The latter means that a single accident more or less than predicted relatively seen has a rather high importance. If the benefit with regard to accidents decreases with 20 % the IRR is 7.4 %, which is an insignificant change for the current example.

5.4.1 Evaluation

The project has a positive NPV and following also an IRR above 5 %, which indicate a socio-economic feasible project. The sensitivity analyses indicate that the project is rather robust towards changes in the basic assumptions, but this is not always the case. If the NPV is relatively small and the IRR just above 5 % even small changes in the assumptions might change the project from being feasible to non-feasible. The assumptions and the non-monetary impacts can for this reason be important for the final decision. The question is also how attractive the project is compared with other projects in a decision situation.

5.5 Non-monetary impacts and other considerations

As previously mentioned a number of impacts exist which have not been valued in the case example. This does not mean that they are not important, but that they are impossible (or very time- or resource consuming) to quantify or assign with a monetary value. In a theoretical case study such as the present these impacts are difficult to assess, so the following will be based on some general reflections.

Environment, nature and recreational areas: The construction of a new motorway will occupy previous nature and agriculture areas, and cause a number of negative impacts on nature and environment, which are not included in the CBA. Motorways especially can have a large impact on the surrounding nature as the road is a barrier to plants and animals even though fauna passages and the like are constructed.

Urban quality, urban barrier impact: Motorways are (normally) not constructed in urban areas, and are for this reason relieving the pressure on the existing road, which often goes through urban areas. Especially the absence of heavy traffic will be experienced as positive impact for the urban areas.

Regional economy: The project must be expected to have a positive impact on the region, as e.g. companies and industries located close to the motorway will get better access to potential workers and the other way around.

Goods transport (industry): It must be expected that especially the local business life will experience advantages due to the project besides the travel time savings. Some businesses can e.g. experience an advantage of being able to reach a larger area within 20 minutes transport.

Other transport modes: The project is not expected to influence other transport modes significantly, hence this is not evaluated. According to the models the traffic transferred from public transport is very small, and it must be assumed that the public level is maintained. In principle reduced revenue from tickets should be deducted from the increased revenue from taxes on fuel according to an assumption on public transport to be public subsidised, this is, however, only very small amounts.

5.6 Presentation of the analysis

In Table 5.7 a scheme with an overview of the project is presented. The scheme contains all relevant information for the decision maker, and is a very useful tool in the presentation of a project and for the final decision making.

Table 5.7: Overview scheme for the case project

Project: Construction of a new motorway		
Purpose: Reduce travel time and improve the safety for the users		
Description: A motorway is constructed between two major cities to relieve the pressure on the existing road		
Basis: The traffic is assumed to be forecasted to the opening year. The construction period commences in 2015 and the opening year (year 0) is set to 2020.		Forecasts: The traffic is forecasted with 1.5 % the first 20 years after opening. All prices are in 2010 level. The time values are forecasted with 1.8 % per year.
Result scheme:		
	Million DKK ¹ , 2010 prices, alternative 1	Million DKK, xxxx prices, alternative 2
Principal item		
Construction costs	-2,038	
User benefits	2,709	
Externalities	641	
Maintenance and scrap value	-63	
Taxes	637	
Tax distortion	-278	
NPV/C_{pub} -rate	0.89	
Internal rate of return	7.6%	
Net present value	1,447	
¹ All numbers are in present values including the net taxation factor.		
Consequences, which is not included in the socio-economic appraisal: In addition to the monetary impacts the project is expected to have negative consequences for the local plant and animal life, and positive consequences for among others the economic growth in the region.		
Uncertainty analysis: The construction costs are the most influential factor with regard to the uncertainty related to the result. A construction cost on 2.8 billion DKK will result in an infeasible project. The project is rather robust towards changes in the user benefits.		

6 Case example II – public transport

In this section a case study concerning a public transport project is presented. The case examines whether it is socio-economic feasible to establish a station on a railway line in an imaginary town named Newtown. The case is – in spite of being imaginary – based on realistic conditions from concrete projects (DMT, 2004).

Two alternatives are examined:

- A new station on the railway line in Newtown and a closure of the bus-service in Newtown
- Maintenance of the current bus-service in Newtown (base alternative)

The appraisal assumes that all trains passing through Newtown – that is one train every hour in both directions – has to stop at Newtown station. That is approximately 12,400 trains per year. The station will result in a 2 minutes increase in travel time for passengers that only travel through Newtown.

6.1 Assumptions

The opening year for the station is assumed to be 2016 (calculation year 1), but as this is an appraisal on an early stage and as the time horizon for being put into operation is very short the alternatives are set up without regard for expected developments in the society until the year of first usage. Thus the appraisal is conducted in correlation with the present traffic and population conditions and in 2013 prices. Hence the prices can be taken directly from the Key Figure Catalogue (at the time of writing this section in February 2014 – check the current price level year before starting a calculation).

The calculation period is set to 50 years, and the calculations of present values for year 0 (2015) are made using a discount rate on 4 % for year 0-35 and 3 % for year 36-49 as recommended by the Danish Ministry of Finance in May 2013.

6.2 Elements in the appraisal

As the appraisal concerns a project which is on a very early stage in the planning process great uncertainties are associated with the estimation of the different elements. For this reason some elements are left out from the appraisal either because the knowledge about the consequences is too limited or because the specific element is estimated to be insignificant for the decision to be made. The case example is thus an illustration of how the appraisal can be structured in an initial planning phase where the need is to examine whether a more detailed basis for decision should be conducted on a later stage.

6.2.1 Construction costs

It is possible to place the station in Newtown rather close to the city centre. No technical or economic assessments of such a stop have been made, but experiences from previous similar projects can contribute to an estimation of the construction costs.

The estimation is based on two platforms (opposite each other), a pedestrian bridge that connects the platforms, and necessary equipment on the platforms (lighting, windbreaks, ticket machines, etc.). This is roughly estimated to cost approximately 11 million DKK.

In addition to the above it is necessary to establish a parking lot for cars and bikes, and an access road and a path to this. The cost for this is estimated to be approximately 3 million DKK. As it is also a request to have access to the platforms in form of elevators the cost will be increased with 8 million DKK.

Based on the estimates above the total costs for the station will be 22 million DKK. The construction costs are primarily expected to be due in 2015 (year 0).

In the socio-economic appraisal the construction costs are to be multiplied with the net taxation factor on 17.1 % as the estimate does not include taxes. The total construction costs can be seen in Table 6.1.

Table 6.1: Construction costs

	Million DKK
Construction costs - actual investment	22.0
Construction costs - incl. net taxation factor	25.8

6.2.2 Scrap value

The scrap value is the value of the construction at the end of the evaluation period, i.e. after 50 years for the present case study. In a situation where the construction is maintained throughout the period the scrap value will correspond to 100 % of the construction costs.

$$\text{Scrap value} = \frac{\text{Construction cost}}{(1+r)^t} = \frac{25.8 \text{ million DKK}}{(1+0.04)^{35} \cdot (1+0.03)^{14}} = 4.3 \text{ million DKK}$$

t is totally set to 49 as we are discounting from the last year in the calculation period (year 49) to the calculation year (year 0).

6.2.3 User impacts

The average value of time on the stretch is 99 DKK/hour. The value of time is in 2013 price level and can be taken directly from the Key Figure Catalogue. The value is expected to grow with the increase in GDP throughout the evaluation period.

In the base situation 60 passengers are using the bus on week days (approximately 325 days/year). It is expected that all 60 passengers will shift to the train once the station has been constructed. The average travel time saving by using the train instead of the bus is estimated to be 15 minutes – some former bus passengers will experience larger savings and some will experience less as there is more than one bus stop in Newtown in the base situation. In total the time benefit is 482,625 DKK/year.

In addition to the above it is expected that 70 new passengers will use the station in Newtown on week days. The utility for travelling by train is different for the new users – some was very close to start using the train already in the base situation while others are only just convinced that it is attractive to use the train (see Section 2.1 on the rule-of-a-half). In the calculations these new travellers will therefore only experience ½ of the time benefit compared to the existing users. I.e. the half of 15 minutes to a value of 99 DKK/hour, this is 281,531 DKK/year.

Approximately 400,000 passengers are travelling through Newtown each year, and of these it is expected that 8,000 will stop using the train due to longer travel time. These travellers will – using the same procedure as with the new travellers – have their utility reduced by ½ the loss of time on 2 minutes. In total this corresponds to 13,200 DKK/year.

The remaining passengers who travel through Newtown will have their travel time prolonged with 2 minutes. This is a negative contribution to the socio-economic calculations on 1,293,600 DKK/year.

Table 6.2 summarises the premises for the calculations outlined above and Table 6.3 shows the total user benefits for the evaluation period in present values.

Table 6.2: Premises for the socio-economic calculations

Element	Premise
Value of time	99 DKK/hour (2013 level)
Growth in GDP	(see Key Figure Catalogue for yearly rates)
Bus travellers, weekdays	60
Time savings, bus travelers	15 minutes
Passenger potential including existing bus travellers, weekdays	130
Conversion factor to year	325
Train passengers travelling through, year	392,000
Lost train passengers, year	8,000
Increased travel time in train	2 minutes

Table 6.3: User benefits in present values (2013 prices)

Component	Present value (DKK)
Time benefit for transferred bus passengers	14,021,357
Time benefit for new train passengers	8,179,125
Time loss for train passengers travelling through	-37,582,030
Time benefit for lost passengers	-383,490

6.2.4 Operating economy, administrator

Maintenance and renewal of infrastructure

The construction of a new station on a railway line will result in increased costs for maintenance and renewal for the infrastructure administrator. It is assumed that the administrator's expenditure for a station like the presented will be approximately 100,000 DKK/year. Including the net taxation factor this is 117,100 DKK/year. Table 6.4 summarises the maintenance costs.

Table 6.4: Maintenance costs in present value (2013 prices)

Component	Present value (DKK)
Maintenance of station	-2,637,937

6.2.5 Operating economy, operator

Changed operating costs for bus and train

A 2 minutes increased travel time for the trains due to the stop in Newtown will primarily increase the operating costs in terms of staff charges. For each single train it is only a small change, but seen over the evaluation period it has a certain effect.

The increased operating costs for trains are calculated as follows: 2 minutes extra driving time for approximately 12,400 trains per year and an estimated cost on 1,539 DKK/hour (including the net taxation factor). Thus the operating costs for the operator are increased with 636,120 DKK/year. This is a pragmatic way of calculating the costs as the schedule is a critical factor for whether the 2 minutes extra driving time will result in real increased driving costs, or if the circulation on the tracks will just be more efficient. Hence the socio-economic result might turn out less costly than indicated here for the operating costs.

Looking at the equipment the 2 minutes extra travel time might result in a need for more train sets. In this case we perform a pragmatic calculation on the need for more train sets as we assumed that each train's circulation time will be increased with 2 minutes every hour in each direction. Thus the increase is $2 \times 2 / 60$ of the yearly write-off cost for this quantity of machinery that a circulation on this stretch is made up of – that is 1 train set. The cost for a train set is 4.62 million DKK/year in 2013 prices (for a regional train, diesel).

In addition to the above the cancellation of the bus service in Newtown will result in a yearly saving for the bus operator. This saving is estimated to be approximately 900,000 DKK/year including the net taxation factor.

Table 6.5 summarises the premises for the calculations outlined above and Table 6.6 shows the changes in operating costs for the evaluation period in present values.

Table 6.5: Premises for the socio-economic calculations

Element	Premise
Increased driving time	2 minutes
Trains stopping each year	12,400
Train operating cost	1,539 DKK/hour
Train acquisition cost	4.62 mDKK/year
Saving on bus operation	900,000

Table 6.6: Changes in operating costs (2013 prices)

Component	Present value (DKK)
Train operation	-14,521,339
Equipment	-6,938,382
Bus operation	20,274,492

Changed ticket revenue for bus and train

The potential for the station in Newtown is as previously mentioned 130 passengers per day. The average ticket revenue for journeys to and from Newtown is estimated to be 23 DKK/journey for both bus and train operators.

With a conversion factor on 325 from weekdays to year the ticket revenue will be increased with 971,750 DKK/year. Due to costs related to the increased sale of tickets 10 % should be subtracted from the amount. Hence the change is 874,575 DKK/year. However, some of the new passengers are changing from bus to train and their previously paid bus ticket should therefore be deducted from this.

It is estimated that 60 passengers are travelling by bus on weekdays between Newtown and the towns which are located along the railway line north and south of the town. By closing the bus service the ticket revenue for these passengers is reduced, i.e. the ticket revenue for the bus operator is reduced by 300,000 DKK/year. A 10 % reduction due to ticket sale is not used here as the ticket sale primarily takes place on the buses.

Finally it is expected that some of the 400,000 passengers travelling through Newtown each year will stop using the train due to the 2 minutes longer travel time. The average travel time for the passengers travelling through Newtown is today 50 minutes. With the time elasticity -0.5 this longer travel time will result in approximately 8,000 passengers stopping to use the train. As a result of this the loss in ticket revenue for the bus operator will be 135,000 DKK/year. From this amount 10 % is subtracted in accordance with the above. Thus the loss is 121,500 DKK/year.

Table 6.7 summarises the premises for the calculations outlined above and Table 6.8 shows the changes in ticket revenue for the evaluation period in present values.

Table 6.7: Premises for the socio-economic calculations

Element	Premise
Increased travel time (train)	2 minutes
Passenger potential	130
Average ticket revenue	23 DKK
Conversion factor to year	325
Bus travellers, weekdays	60
Train passengers travelling through, year	392,000
Reduction in train passengers, year	8,000

Table 6.8: Changes in ticket revenue (2013 prices)

Component	Present value (DKK)
Revenue new travellers, train	25,408,398
Revenue travellers, bus	-8,715,684
Revenue previous travellers, train	-3,529,852

6.2.6 Taxation

The state will lose the net taxation factor as a result of the change in ticket revenue from the new travellers by train. This due to the fact that train and bus travels are not subjects to taxation. The state will lose 0.171/1.171 of the net ticket revenue on 453.075 DKK/year, i.e. 66.162 DKK/year.

Table 6.9 shows the change in tax revenue for the evaluation period in present value.

Table 6.9: Changes in tax revenue (2013 prices)

Component	Present value (DKK)
Taxation, state	-1,922,157

6.2.7 Distortion

Distortion loss is an expression for the socio-economic loss that takes place when the state's expenses are financed by taxes. All costs and benefits for the state (construction costs, operating costs and ticket revenues) have a negative contribution to this. The distorting effect is calculated as 20 % of the change before potential multiplication with the net taxation factor. Regarding the ticket revenue for the train operation the net taxation factor is deducted before calculating the distortion effect. This as the state before the change obtained this revenue from alternative usage of the funds, which are now used for purchasing train tickets.

The distortion effect in present value is shown in Table 6.10.

Table 6.10: Distortion effect (2013 prices)

Component	Present value (DKK)
Distortion	-2,978,993

6.3 The total socio-economic appraisal

The total socio-economic appraisal includes all the impacts that are converted into monetary values and discounted to year 0 (in this case year 2015). Table 6.11 summarises the components of the appraisal and presents the results.

Table 6.11: The result of the socio-economic appraisal

	Present value (DKK)
Construction costs	-25,762,000
Scrap value	4,322,467
Operation and equipment (incl. ticket revenue), train operator	418,825
Operation (incl. ticket revenue), bus operator	11,558,808
Maintenance of station	-2,637,937
User benefits	-15,765,038
Tax revenue, state	-1,922,157
Distortion effect	-2,978,993
NPV	-32,766,025
IRR	-
NPV/C_{pub}	-1.08

In addition to the monetary appraisal a number of non-monetised impacts are considered as well. The assessment of their influence is summarised in Table 6.12.

Table 6.12: Assessment of non-monetised impacts

	Effect
Impacts during construction	Negative
Air pollution and noise	?
Accidents	Somewhat positive
Renewal of station	Negative
Energy consumption, train	Somewhat negative
Urban development and real estate prices	Positive
Visual environment	Negative

The appraisal shows that it is not economic feasible to place a new station in Newtown. Only the bus operation reveals stable benefits while the benefits for the train operation is almost insignificant in the total picture. The remaining components contribute negatively to the economy.

The result of the appraisal is caused by too high construction costs compared to how many passengers will use the new station. In addition to this the number of new travellers to/from Newtown is too small compared to the number of passengers that travel through the town and experience a longer travel time.

As the socio-economic appraisal is conducted on an early stage in the decision process the following impacts have not been considered: Impacts during construction, air pollution, noise, renewal of the station, change in the trains' energy consumption, and change in road driven kilometres (as this is expected to be very small). Moreover, it is relevant to consider changes in urban development and real estate prices as well as visual environment. This is shortly described below.

6.3.1 Impacts during construction

The construction of a new station will necessitate occasional blockages of one or both tracks in limited time periods, which will affect the train operation negatively as delays will occur. The delays will cause longer travel times for the passengers, and some passengers might stop using the train for this reason, and this will cause reduced ticket revenue. In addition to this the costs for train operation will be increased due to collective agreements, and as a result of this the distortion effect will be changed. The total impact of the construction period will be negative.

6.3.2 Air pollution and noise

The air pollution and noise will be increased around the railway when the trains have to do an extra stop in Newtown. However, the air pollution and noise from buses will be reduced due to the cancellation of the service. Whether the total impact will be positive or negative is difficult to state at this stage, but the impact will be small.

6.3.3 Accidents

The risk of accidents in the traffic is reduced by closing the bus service and transferring the passengers to train. This is a result of fewer kilometres driven by bus and an unchanged number of kilometres driven by trains. The effect, however, is very small.

6.3.4 Renewal of station

During the 50 year evaluation period it will be necessary to perform occasional renewal of the station equipment. The renewal during the first part of the period is minimal as the station is brand new. Later expenses due to renewal might be quite large (larger than 1 million DKK), but will due to discounting be close to insignificant in the calculations.

6.3.5 Energy consumption and maintenance, train

The calculations do not address the fact that the trains' energy consumption will be increased as a result of an extra stop. This can be difficult to estimate without detailed model calculations. Conventionally the

cost for maintenance is linked to the change in driven kilometres, which in this case is unchanged except for the small increase in the number of train sets on 0.07. It is fair to regard this number as insignificant. The extra stops will increase the energy consumption a little. Thereby the distortion effect will be more negative while the tax revenue will be positively affected.

6.3.6 Visual environment

The visual environment will be affected by establishing a new station in Newtown. Whether the environment will be positively or negatively affected is a matter of subjective judgment, but especially the neighbours to the new station and pedestrian bridge will most likely not be in favour of the constructions. The close neighbours will moreover suffer from free view to their gardens from the platforms and pedestrian bridge. Installing screens will reduce this, but it will not improve the visual environment.

6.3.7 Urban development and real estate prices

Establishing a station in Newtown will no doubt increase the settlements in the town and thereby increase the real estate prices. With newcomers and better accessibility to the town there will also be a good basis for developing the towns business and culture life.

6.4 Presentation of the analysis

In Table 6.13 a scheme with an overview of the project is presented. The scheme contains all relevant information for the decision maker, and is a very useful tool in the presentation of a project and for the final decision making.

Table 6.13: Overview scheme for the case project

Project: Establishing a new station in Newtown																					
Purpose: The socio-economic appraisal is to examine whether there is an economic basis for establishing a new station in Newtown. A new station will provide the citizens in the area direct access to the train and thereby improved travel time compared to the existing bus service of the town. However, the existing passengers in the train will experience a longer travel time.																					
Description: Two alternatives are considered: <ul style="list-style-type: none"> • A new station on the railway line in Newtown and a closure of the bus service in Newtown • Maintaining the current bus service in Newtown (base alternative). The appraisal considers the difference between these two alternatives and presents the socio-economic impacts by establishing the station. The appraisal assumes that all trains passing through Newtown - that is one train every hour in both directions - has to stop at Newtown station. That is approximately 12,400 trains yearly. The station will result in a 2 minutes increase in travel time for passengers that only travel through.																					
Basis: The base alternative corresponds to the present situation with bus service in Newtown and a train passing through every hour in each direction.	Forecasts: All prices are in 2013 level. After putting the station into operation a constant number of passengers are assumed throughout the evaluation period.																				
Result scheme: <table border="1"> <thead> <tr> <th>Principal item</th><th>Million DKK¹, 2013 prices</th></tr> </thead> <tbody> <tr> <td>Construction costs, scrap value and maintenance</td><td>-24,1</td></tr> <tr> <td>User benefits</td><td>-15,8</td></tr> <tr> <td>Operating costs incl. equipment, train operator</td><td>0,4</td></tr> <tr> <td>Operating costs, bus operator</td><td>11,6</td></tr> <tr> <td>Tax revenue, state</td><td>-1,9</td></tr> <tr> <td>Tax distortion</td><td>-3,0</td></tr> <tr> <td>Benefit-cost rate</td><td>-1,08</td></tr> <tr> <td>Internal rate of return</td><td>-</td></tr> <tr> <td>Net present value</td><td>-32,8</td></tr> </tbody> </table>		Principal item	Million DKK ¹ , 2013 prices	Construction costs, scrap value and maintenance	-24,1	User benefits	-15,8	Operating costs incl. equipment, train operator	0,4	Operating costs, bus operator	11,6	Tax revenue, state	-1,9	Tax distortion	-3,0	Benefit-cost rate	-1,08	Internal rate of return	-	Net present value	-32,8
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Tax distortion	-3,0																				
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Internal rate of return	-																				
Net present value	-32,8																				
¹ All numbers are in present values including the net taxation factor.																					
Consequences, which is not included in the socio-economic appraisal: In addition to the monetary impacts the project is expected to have negative consequences for impacts during construction, renewal of station, energy consumption and visual environment, and positive consequences for accident, urban development and real estate prices. The impact on air pollution and noise cannot be estimated on the current stage.																					
Uncertainty analysis: Has not been conducted for the present case as the results of the conventional appraisal reveal an unfeasible project																					

7 Summary

Cost benefit analysis (CBA) is a tool which is intended to aid decision-taking in the public sector. It is the basic member of the family of investment appraisal methods. A 'pure' CBA involves the enumeration and valuation in monetary terms of all the costs and benefits, to whomever they accrue, over the life of the project or policy intervention being evaluated. Future costs and benefits should be expressed in present value terms using an appropriate discount rate. The basic criterion that a project has to satisfy in a CBA is that it has a *positive net present value*, i.e. the benefits exceed costs over its lifetime.

CBA, when applied to transport interventions and projects, takes travel time savings to be of real value to travellers. In practice, certain valuation conventions are used to value time benefits, and since on average 85-90% of the monetised benefits of major road schemes come in the form of time savings, the cost benefit results are sensitive to the conventions that are followed (SACTRA, 1999).

The CBA method is generally most appropriate in cases where there are no important distribution effects, and where there are no decidedly strategic/political issues. For the CBA to be sufficient there should generally not be any important effects which are not assigned a monetary value. If this is the case, CBA should be supplemented with qualitative (and possibly quantitative) analysis that addresses these special effects. When such additional tests are added to the CBA it may be useful to combine the CBA with a multi-criteria decision analysis (MCDA), which can assist the strategic effects as part of a comprehensive assessment.

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